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R&D Funds Set for Record \$66 Billion in '81

Nationwide spending for research and development will hit a record peak of \$66.7 billion next year, and for the sixth consecutive year, the R&D growth will match or outstrip the rate of inflation.

The improbable but reliable finding is contained in the latest of the National Science Foundation's periodic reports on the financial status of American R&D. While the shouts and alarms coming from academe and industry do suggest that painful shortages have developed in several sectors of the research enterprise (See Page 6), the NSF tabulations strongly indicate that, on the whole, R&D is faring quite well in these difficult times. And that appears to apply even to the traditionally vulnerable field of basic research, which, in past crises, was the first to feel the axe as money became tight.

Thus, NSF observes that within the grand total of spending, "proportionately more funds have been

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allocated to basic research—from 35 per cent of the research total in 1975 to nearly 40 per cent in 1981." NSF's politically neutral report writers evenhandedly credit this to "recent administrations' policies," by which they mean it began under Ford and was carried on by Carter.

As for where the growth is coming from, the answer is energy, environmental studies, and "a resurgence of defense R&D activity." But what's also important to note is that as a result of a longrunning, year-by-year process, industry has finally surpassed the federal government as the largest single supporter of R&D. "By 1979," NSF notes, "the federally funded portion of national R&D expenditures had dropped from 65 per cent in 1965 to 49 per cent and is expected to drop another percentage point over the next two years, mainly as a result of expected increases in industry's own R&D funding."

What this means for the politics of science is difficult to say, especially since the federal-industrial proportions vary by research sector; the federal government, for example, still supports some 70 per cent of all basic research.

But what's evident from these numbers and the trends they suggest is that Washington is no longer the solo powerhouse of American research and development.

Throughout most of the postwar period, it was Congress, the White House and the executive branch research agencies that called the signals for science and technology. These entities remain very important in setting priorities for R&D and in allocating funds around the country. But, with industrial R&D spending pointed up while the federal government's share is drooping, Washington has important company in the governance of research.

The NSF study found that while federal R&D support increased by nearly 15 per cent, in constant dollars between 1975 and 1979, industry boosted its spending by nearly 25 per cent during the same period. Much of industry's growth was concentrated in energy and environmental programs; a large chunk of the federal increase was for defense-related R&D.

In the much-discussed area of international comparisons, the US, with 2.3 per cent of GNP devoted to research and development, is second only to West

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In Brief

The big study of science and engineering education ordered in February by President Carter was delivered last month, on schedule, to the White House by NSF and the Department of Education—and bucked right back for further work. Seems the recommendations accompanying the gloomy assessment were too feeble and the President's science staffers wanted stronger stuff.

Opening line of a June 27 letter from Academy of Sciences President Philip Handler to Clyde E. Shorey Jr., head of the National Coalition for Disease Prevention and Environmental Health: "This acknowledges your quite outrageous letter of 18 June." Shorey, like many others, had criticized the Food and Nutrition Board's exoneration of cholesterol (SGR Vol. X, No. 11).

Biomedical politicians are lobbying hard against two Congressional measures that would markedly affect NIH: Rep. Henry Waxman's bill (HR 7036), which would set time and dollar ceilings on NIH appropriations, and Senator Edward Kennedy's bill (S. 988), which would put a President's Council for the Health Sciences atop the Department of Health and Human Services. The Kennedy bill has been passed by the Senate; Waxman's has cleared committee.

R&D Money: The Providers and the Receivers

Year	Total	Federal Government	Industry ¹	Academic sector		Other nonprofit institutions
				Universities and colleges	Associated FFRDC's ²	
(Dollars in millions)						
By performer						
1975	\$35,256	\$ 5,397	\$24,187	\$3,409	\$ 987	\$1,276
1976	38,960	7,710	\$26,997	3,730	1,147	1,376
1977	43,013	6,142	29,928	4,064	1,384	1,495
1978	48,286	6,882	33,400	4,615	1,717	1,672
1979 (prelim.)	54,296	7,500	37,622	5,340	1,840	1,994
1980 (est.)	60,375	7,830	42,250	6,050	2,000	2,245
1981 (est.)	66,700	8,500	47,000	6,650	2,200	2,350
By source						
1975	35,256	18,152	15,820	750	—	534
1976	38,960	19,844	17,694	821	—	601
1977	43,013	21,751	29,696	893	—	673
1978	48,286	24,058	22,433	1,029	—	766
1979 (prelim.)	54,296	26,762	25,520	1,150	—	864
1980 (est.)	60,375	29,400	28,710	1,300	—	965
1981 (est.)	66,700	32,000	32,210	1,450	—	1,040

¹Includes expenditures for federally funded research and development centers (FFRDC's) administered by this sector. They account for less than 5 percent and 15 percent, respectively, of the industry and nonprofit performance totals.

²FFRDC's administered by individual universities and colleges and by university consortia.

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Germany, by a small margin. In terms of total expenditures, however, NSF found this country far ahead of its industrial competitors. "If the domestic scene is compared to the international picture," the report states, "it is evident that the United States spends more than any other nation on R&D activities—at least twice the total amount spent by any other major Western country or Japan." What's left out of that is that the US spends well over half of its government R&D funds on defense research, while Germany spends perhaps 10 per cent and Japan far less than that.

Nonetheless, the report optimistically hints that a big economic bounty may result from the post-1975 increase in R&D spending. "Although the temporal relationship between input and impact is not clearly understood," it states, "it is generally accepted that research and development eventually lead to economic gains and productivity increases. It is agreed, however, that the

full economic impact of R&D spending is generally not realized in the short term and that the full effect of the recent constant-dollar R&D growth on the economy may not be felt for several years."

How will this growth affect R&D employment? The NSF study predicts that fulltime-equivalent employment of R&D scientists and engineers will continue upwards. It rose from 518,000 in 1972 to 602,000 in 1978, and NSF puts the 1980 figure at 660,000. "All sectors of the economy," it states, "are expected to share in the increase, with the largest absolute growth to occur in industry, particularly in areas with a heavy reliance on engineering."

(The NSF report containing these and other data is available without charge from: Division of Science Resources Studies, National Science Foundation, 1800 G St. Nw., Washington, DC 20550; request NSF Publication 80-310.)

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Editor and Publisher
Daniel S. Greenberg

Associate Publisher
Wanda J. Reif

Contributing Correspondents

Anne Roark, Clive Cookson (Washington); Michael Kenward (London); Francois Seguier (Paris)

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NSF Nominee Awaits the Call to Capitol Hill

There's some concern being privately expressed in science-policy circles about the possibility of the National Science Foundation directorship getting tangled in election-year politics.

The chance for this happening arises from the fact that now-vacant post, for which John B. Slaughter, provost of Washington State College, has been nominated, comes with a six-year appointment. And some Republicans, believing they are enroute to regaining the White House, aren't disposed to having a Democratic President make a choice that could extend beyond the next presidential term. The NSF Director serves out that term, "unless sooner removed by the President," but that's never happened, and it would very likely be a messy business, the more so since Slaughter would be the first black to hold the position.

As of late July, Slaughter, who initially turned down the job and then agreed to take it after Carter himself got on the phone, was still at Washington State College, awaiting word on when his confirmation hearing will be held. Presidential interest in this relatively low-level and politically inconspicuous post is sufficiently odd to arouse various interpretations—all of them pointing toward November 4. White House aides have been putting out the word that Carter was determined to sign up Slaughter for the job, even though he wasn't on the short list recommended by the National Science Board. The explanation for that was that Slaughter was left off because he had indicated he wasn't interested. What the beleaguered Administration is getting, on a two-for-the-price-of-one basis, is a highly qualified chief for an agency important to the scientific community, and evidence of its commitment to expanding opportunities for blacks.

As for the confirmation hearing, it's of the kind that is usually short and sweet, but with the Democratic National Convention coming up, and the Senate suddenly undertaking a Billy Carter investigation, NSF sources say they can't get any word on when Slaughter will be invited to Capitol Hill. If Republicans want to put a "hold" on the appointment, that wouldn't be too difficult at this late stage of the legislative season.

Meanwhile, the Foundation is headed on an acting basis by its number two official, Donald N. Langenberg, also a newcomer to the organization, having recently come to NSF from the University of Pennsylvania. He succeeded Deputy Director George Pimentel, who returned to the University of California, Berkeley, and was routinely confirmed by the Senate last month.

And, then, too, there are still seven gaps on the National Science Board, the policymaking body of the Foundation. The White House, which obviously isn't

paying much attention to these matters, was advised months in advance that these vacancies would routinely occur May 15 through the expiration of the members' terms, but it wasn't until June 20 that the President announced the nominations, which also require Senate confirmation, as yet unscheduled. The nominees are:

Peter T. Flawn, President, University of Texas

Mary L. Good, Boyd Professor of Materials Science, Louisiana State University

Peter D. Lax, Director, Courant Institute of Mathematical Sciences, New York University

Homer A. Neal, Professor of Physics, Indiana University

Mary Jane Osborn, Professor of Microbiology, University of Connecticut Health Center

Stuart A. Rice, Frank P. Hixon Distinguished Service, Professor of Chemistry, The James Franck Institute, University of Chicago

Donald B. Rice Jr., President, Rand Corporation, renominated for a second term.

Grants for Science, Ethics Study

Grants for a new round of scholarly agonizing over the implications of science and technology have been announced by the two cashiers for this venture, the National Science Foundation and the National Endowment for the Humanities. Together, they're putting up \$547,000 for 16 projects designed, as an NSF press release puts it, "to examine the ethical and social dimensions of science, engineering and medicine."

The announcement adds that the money "will enable scholars and students of the humanities to collaborate on studies of the social values that affect a scientist's choice of research topics, ethical questions raised in the conduct of research and engineering, and dilemmas that scientists and physicians face in communicating complex or ambiguous research findings to those affected by their studies."

Twelve of the awards are for individual projects; the other four "will enable established scholars to assist colleges and professional schools to develop research and teaching programs in science and values."

Cooper Joins Upjohn Co.

Theodore M. Cooper has announced that he'll resign October 1 as dean of Cornell Medical College to become Executive Vice President of the Upjohn Co. Cooper formerly was Assistant Secretary for Health in the old Department of Health, Education, and Welfare, and prior to that directed the National Heart Institute.

Republican Platform Makes Nod to Research

That wordy platform (78 pages of it) adopted July 15 by the Republicans says relatively little about research and related matters, and most of what it offers in that area is in the context of national security.

It is under the sectional heading of "National Security" that "Research and Development" makes its only appearance in the platform—for all of five paragraphs (see box).

As for other matters in the neighborhood of science, technology, and higher education, the platform offers a slightly denatured version of Mr. Reagan's past pledges to abolish the Department of Education, saying only that the Party "encourages the elimination of the federal Department of Education." Deans and other mandarins in academe will be pleased to find the platform declaring, "We hold the federal bureaucracy accountable for its harassment of colleges and universities and will clean away the tangle of regulation that has unconscionably driven up their expenses and tuitions."

Mr. Reagan's other departmental abolition promise, this one concerning the Department of Energy, gets even less support in the platform, which touches on the subject only indirectly. After making a number of unpleasant remarks about Energy and Education, the platform, under the heading of "Government Reform," expresses favor for a blue ribbon commission "to recommend ways of reorganizing and reducing the size and scope of the Federal Branch." One reason that the platform writers may have backed off from axing the Department of Energy is that they're awash with all kinds of big energy schemes that, at least up to now, have been paid for and administered by the DOE. These include the fast breeder demonstration reactor, nuclear waste storage, and research on alternative fuels.

The platform doesn't so say directly, but, in effect, it calls for elimination of the Delaney Amendment, which prohibits the addition to human foodstuffs of any substance known to cause cancer in animals. Wiping out that barrier has become the central goal of a bunch of strange political bedfellows, ranging from the food industry, through academe and the National Academy of Sciences. The platform item simply says: "The Republican Party favors a legislative effort to revise and modernize our food safety laws, providing guidelines for risk assessment, benefit assessment, peer review, and regulatory flexibility which are consistent with other government health and safety policies."

Though the platform calls for elimination of curbs on US grain sales to the Soviets, it concludes, with schizophrenic agility, that we ought to stop selling them technology "that could contribute, directly or indirectly, to the growth of their military power." The extent of the proposed trade denial isn't clearly spelled out, but the

The following, headed Research and Development, is from the National Security section of the 1980 Republican Party Platform:

Research and Development (R&D) provides a critical means by which our nation can cope with threats to our security. In the past, the United States' qualitative and technological superiority provided a foundation for our military superiority. Yet we are now on the verge of losing this advantage to the Soviet Union because of Mr. Carter's opposition to real increases in the R&D effort. Delays imposed on the R&D process now allow seven to 10 years or more to elapse between the time when a new weapon system is proposed and when it becomes available.

The Soviet Union now invests nearly twice as much in military research and development as does the United States. This disparity in effort threatens American technological superiority in the mid-1980s and could result in Soviet breakthroughs in advanced weapon systems.

Republicans pledge to revitalize America's military research and development efforts, from basic research through the deployment of weapons and support systems, to assure that our vital security needs will be met for the balance of the century. We will seek increased funding to guarantee American superiority in this critical area and to enable us to deal with possible breakthroughs in anti-missile defense, anti-satellite killers, high-energy directed systems, and the military and civilian exploitation of space.

America's technological advantage has always depended upon its interaction with our civilian science and technology sector. The economic policy of the Carter Administration has severely encumbered private research and development efforts, thereby depriving both our civil and military sectors of the fruits of scientific innovation.

Underfunding of beneficial government-sponsored research efforts in basic and applied scientific research has disrupted the benefits of years of effective effort. In particular, America's preeminence in the exploration of space is threatened by the failure of the Carter Administration to fund fully the Space Shuttle program (with its acknowledged benefits for both the civil and military applications) as well as advanced exploration programs. Republicans pledge to support a vigorous space research program.

above quotation follows references to "electronics, computer sciences, manufacturing techniques, mining, transportation, aviation, agriculture, and a host of other disciplines."

Global 2000 Study Paints Gloomy Future

The US government last week released its long-gestating *Global 2000 Report*, claiming it to be the most comprehensive set of projections ever made of changes in world population, resources and environment, either by governments or by private forecasters.

The study's portrait of the world in 2000—"more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now"—is rich in depressing details, among them, for example, that 15-20 per cent of today's plant and animal species will have been wiped out by 2000, mainly because 40 per cent of the world's tropical forests will have been cut down.

In his May 1977 Environmental Message to Congress, President Carter ordered the Council on Environmental Quality (CEQ) and the State Department to undertake the *Global 2000* study as a one-year project, in cooperation with other federal agencies. The two-year delay in completing it is attributable not only to grave defi-

Copies of *Global 2000* are available from: Superintendent of Documents, USGPO, Washington, DC 20402.

Volume I, a 47-page summary of findings, is priced at \$3.50 per copy. Specify No. SN041-011-00037-8.

Volume II, a 766 page "technical report," costs \$13 per copy. Specify No. SN041-011-00038-6.

A third volume, containing modeling data, is in preparation and is scheduled for publication this fall.

ciencies in the government's modeling capabilities but also to the time taken simply to write the report, particularly the 47-page summary of the 766-page technical volume. The authors have clearly taken great care to present the projections in as gloomy a way as possible.

For example the summary plays down the projection that real economic growth will continue for the remainder of the century—at an average annual rate of 4.5 per cent in the less-developed countries (LDCs) and 3.3 per cent in the industrialized world—and that even in the poorest regions, there will be some increase in GNP per capita. Instead it emphasizes the fact that, in absolute terms, "the large existing gap between the rich and poor nations widens."

Other bright spots include: world food production up 90 per cent between 1970 and 2000, with a per capita increase of 15 per cent overall and 9 per cent in the LDCs; no worldwide energy crisis (though LDCs will experience serious difficulties because of the rising price of oil and a grave shortage of firewood), and generally sufficient supplies of nonfuel minerals.

Obviously the authors buried the good news and played up the bad, presumably to obtain the maximum

impact on public and political opinion at home and abroad. Their message, as President Carter put it, is that "the conditions the report projects are by no means inevitable. In fact its projections can and should be timely warnings which will alert the nations of the world to the need for vigorous, determined action, at both the national and international levels."

But the writers may also have wanted to counter-balance what the report calls an "optimistic bias" in the projections themselves. The bias is due mainly to the fact that the government does not have a single, integrated global model. Individual agencies have their own sectoral models, created at different times, using different methods, to meet different objectives, and little thought has been given to relating these often inconsistent models to one another, to project a comprehensive, consistent image of the world.

The *Global 2000 Report* confesses that, after three years' work, the study did not really succeed in harmonizing and integrating the projections; "many internal contradictions and inconsistencies could not be resolved." For example most of the individual projections in the report (for food, minerals, energy, etc.) assume that enough capital, energy, water and land will be available to meet the needs of that sector, regardless of the competing needs of other sectors.

"More consistent, better integrated projections would produce a still more emphatic picture of intensifying stresses, as the world enters the 21st century," the report says. It tested that statement by cutting linkages in two simpler but better integrated nongovernmental models (sponsored by the Club of Rome) and discovering that their outcomes then became distinctly more favorable.

(On a broad scale, the *Global 2000* projections agree fairly well with world models produced under the auspices of the Club of Rome, the United Nations and other organizations. However, by stopping only 20

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Solar Satellite Views Sought

Anyone worried about the hazards of collecting solar energy in space and beaming it to earth is invited to share his or her concerns with a new group that's studying the crackpot scheme: It's a committee set up by the National Academy of Sciences' National Research Council. Address: Satellite Power Systems Committee, Environmental Studies Board, NAS, 2101 Constitution Ave. NW., Washington, DC 20418; telephone (202) 389-6917.

DOE Labs Hurting, Despite House Support

The budget that sustains most of the nation's physics research has been given a partial reprieve from Washington's anti-spending stampede. But even so, several major laboratories of the Department of Energy have been forced to cut research and lay off staff to remain within their spending limits.

The first step toward preventing the situation from becoming even worse came when the House voted to restore much of the money for energy research that had been cut earlier this summer by the Appropriations Committee. Under the committee's plan, the Department of Energy's Office of Energy Research faced a \$110-million reduction in the \$1.2-billion request for fiscal 1981 made by President Carter.

What is perhaps most surprising about the proposal to restore the funds for basic energy research is that it was made by a fiscal conservative—Rep. Don Fuqua (D-Fla), Chairman of the Science and Technology Committee.

"I am not one that stands in this well and offers spending amendments," Fuqua told his colleagues on the House floor. "[I]f my memory does not fail me, this is the first time in 18 years that I have been in this body that I have ever offered an amendment to increase funding in an appropriation bill. I hope it is the last time. . ."

Fuqua's proposal was to restore \$85.1 million for

operating expenses in DOE, plus \$2.8 million for plant and capital equipment, and \$19.5 million for operating expenses for general sciences. The plan was endorsed by the Administration, as well as the American Council on Education, the National Association of State Universities and Land-Grant Colleges, and several research organizations.

Rejecting most of the cuts that the Appropriations Committee had voted for DOE's Office of Energy Research, the House came out for funding levels pretty close to what the Administration had recommended in the first place. Thus, magnetic fusion would receive \$394 million, compared with the Administration's request of \$396.1 million. High-energy physics would receive \$228.2 million, compared with the \$242.2 million requested by the President. Nuclear physics would receive \$87.84 million, compared with the Carter request of \$88.8 million. And basic energy sciences would receive \$227.3 million, compared with the budget request of \$229.5 million. The increases, however, do not mean that these research programs are safe from the problems of inflation. Indeed, many of those programs already have suffered crippling setbacks in recent months.

Many of the federal energy-research laboratories, for example, have halted experiments and closed supply

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GLOBAL 2000 *(Continued from Page 5)*

years from now, *Global 2000* does not have to consider the likelihood of an apocalyptic global collapse during the first half of the 21st century, which some of the longer-term models suggest.)

Improving the government's ability to analyze long-term global trends will be a priority for the Presidential Task Force on Global Resources and Environment, chaired by CEQ chairman Gus Speth, which Carter has established to follow up *Global 2000*. Within six months it is supposed to produce its first policy recommendations for dealing with the problems identified in the study.

Meanwhile, the State Department plans to spotlight the report at appropriate international meetings, and the findings have already been dispatched to American embassies round the world, for transmission to foreign governments, and science attaches in Washington have been fully briefed on it.

Mostafa Tolba, executive director of the UN Environment Program, called *Global 2000* "an exemplary initiative" and, in an effusive message of praise, commended it "to the consideration of the entire world

community." Like CEQ's Gus Speth, Tolba sees the report as a companion to the World Conservation Strategy launched by various international agencies earlier this year. Together, he said, they provide "both a technical data base and a set of procedures whereby it is now possible to deal in earnest with the management of the planet's very precarious resources."

The Administration will of course be pleased by this praise from abroad, but it is also looking for a favorable response at home, particularly in Congress. Carter and his staff may or may not use *Global 2000* as an environmental stick with which to attack Ronald Reagan, but Secretary of State Muskie has indicated that he will use the report in seeking funds for foreign aid and international development from Congress.

"Our commitment ought to be a national embarrassment, whatever the motives of the opponents" of foreign aid, Muskie said. "*Global 2000* demonstrates, I think, just how important our investment in the welfare of our neighbors can be, and just how great are the human costs of shortsighted policies."—Clive Cookson

(The author is Washington correspondent of the *London Times Higher Education Supplement*.)

... Layoffs and Program Cuts at Some Labs

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rooms for the summer. Some have even laid off scientists and technicians. At the Brookhaven National Laboratory, Long Island, nearly 30 scientists, technicians, and other personnel have been laid off, and a plan has been drawn up to reduce overhead costs. If federal support is reduced substantially in the months ahead, laboratory officials say, they will have to shut down operations for perhaps several months.

At the Fermi National Accelerator Laboratory, Batavia, Ill., major experiments have been curtailed for the remainder of the summer, and employees are being asked to take vacations without pay, according to Leon M. Lederman, Director of the center.

Even the Stanford Linear Accelerator Center in Palo Alto, Calif., site of the nation's newest accelerator, is feeling the pinch of the tightening federal budget, according to its director, Wolfgang Panofsky.

The cutbacks, most of which occurred this summer, have imposed particular hardships on university researchers who are forced to schedule most of their lab-

oratory work during the months when school is not in session.

Part of the fiscal problem is caused by the rising costs of conducting energy research, coupled with the stringent budgets that research programs have received in the past year. But the financial problems have been exacerbated by a \$44-million recession in the Department of Energy's 1980 budget which Congress approved this summer.

At a meeting at Fermilab this spring, researchers representing the major physics laboratories warned that the cuts could mean that hundreds of staff members would be laid off and research sharply curtailed.

In a recent interview with the *New York Times*, Frank Press, the White House science adviser, expressed concern about the financial plight of the accelerator laboratories.

"This notion that these accelerators, which have made American science so famous at the cost of huge capital investments, should have to be turned off for lack of operating money is astounding to me. I have communicated the concern of the Administration to the Appropriations Committee."

Astounding though it may be to the White House science adviser, it's not so astounding to Congress, which is yet to swallow the old argument that somehow it's sinful if science does not proceed as fast as it can go. The legislators are a bit more receptive to the claim that it's highly wasteful to build these expensive machines and then underutilize them.

But with American politics and economics in topsy-turvy condition, the wails of the particle physicists are difficult to distinguish from among similar sounds coming from nearly all segments of society.

Academy Names Executives

David C. Hazen, professor of aeronautical engineering at Princeton University, has been named Executive Director of the Assembly of Engineering at the National Academy of Sciences. He succeeds Micah H. Naftalin, who has been appointed assistant to the chairman of an Academy committee studying risk assessment. Also, Thomas B. Deen, a consulting transportation engineer, has been appointed Executive Director of the Academy's Transportation Research Board, succeeding William N. Carey Jr., who has moved to the job of Associate Executive Director of the NAS Commission on Sociotechnical Systems.

The National Research Council, which is the operating arm of the Academy, also announced the following appointments:

Herbert Friedman, Chief Scientist Emeritus, Center for Space Research, US Naval Research Laboratory, will chair the Assembly of Mathematical and Physical Sciences, 1980-83, succeeding Jacob Bigeleisen, Vice President for Research, State University of New York, Stony Brook, who held the Assembly post since 1976.

Robert M. White, who recently resigned as Executive Officer of the Academy to become President of the University Corporation for Atmospheric Research, Boulder, has been appointed chairman of the NAS Commission on Natural Resources, 1980-83. He succeeds Gilbert F. White, of the Institute of Behavioral Science, University of Colorado, Boulder, who was chairman since 1977.

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France: "Big Science" Gets a Budget Boost

Paris. An ambitious national and international program for big science is evident in the research and development segment of the latest longrange planning exercise now underway here.

According to a paper prepared for the office of the Secretary of State for Research, annual funding for the support of major R&D facilities, currently \$177 million, will be increased to an inflation-adjusted minimum of \$197 million after 1981. The increase is set forth in a White Paper prepared under the direction of Jean Tillac, the High Commissioner for Atomic Energy, who has long been warning of the inflationary erosion of support for big science. Thus, considering the source of the spending plan, it is not surprising to find of 16 projects listed for the 1980s, nine deal with atomic or subatomic physics. Among the projects are:

- The recently agreed-on new facility at the European Center for Nuclear Research (CERN), the Electron Positron Laboratory (LEP), toward which France will contribute startup funds of \$8.4 million.

- The National Accelerator for Heavy Ions (GANIL), under construction at Caen, in Normandy, which will go into operation in about two years; total construction cost is estimated at \$115 million.

- Renovation of the high neutron flux facility at Grenoble, which France operates in collaboration with Britain and West Germany; the French contribution for modernizing the facility will amount to \$9 million.

- A new neutron source, to be known as ORPHEE, to be constructed at Saclay, near Paris, which is the main center for French nuclear research; total cost will

be about \$62 million.

- Continued updating of SATURNE, the old particle accelerator at Saclay, for about \$1 million a year.

- Collaboration with Euratom, the Common Market nuclear agency, on construction of a fusion machine, the TORE-SUPRA tokamak, at Cadarache, in the south Alps; the cost will be about \$64 million, with Euratom paying half.

- Continued support of construction of the Common Market's tokamak, the Joint European Torus, at Culham, England. France will pay about 20 per cent of the total \$376 million for building the machine.

- A high-power laser facility for the armed services, PHEBUS, which is expected to cost \$72 million. Completion is scheduled for 1985.

For many of these projects, France has opted for international solutions, whether by contributing to the financing of a European machine, or by opening the doors of its laboratories to its neighbors. The same applies to the programs of the European Space Agency, which receives \$29 million per year from France. France also collaborates in space with the two super-powers: Spacelab with the US, and Venera for the Soviet Union, a Franco-Soviet program for the exploration of Venus, which will develop in two stages, one before 1981 (\$4 million), and a second from 1985 to 1990.

Three other large projects will be undertaken solely by France: Themis, a thermodynamic solar center being built in the Pyrenees near Spain (\$25 million); a new fleet of oceanographic ships (\$39 million after 1985) and a \$10 million pig breeding station.—F.S.

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